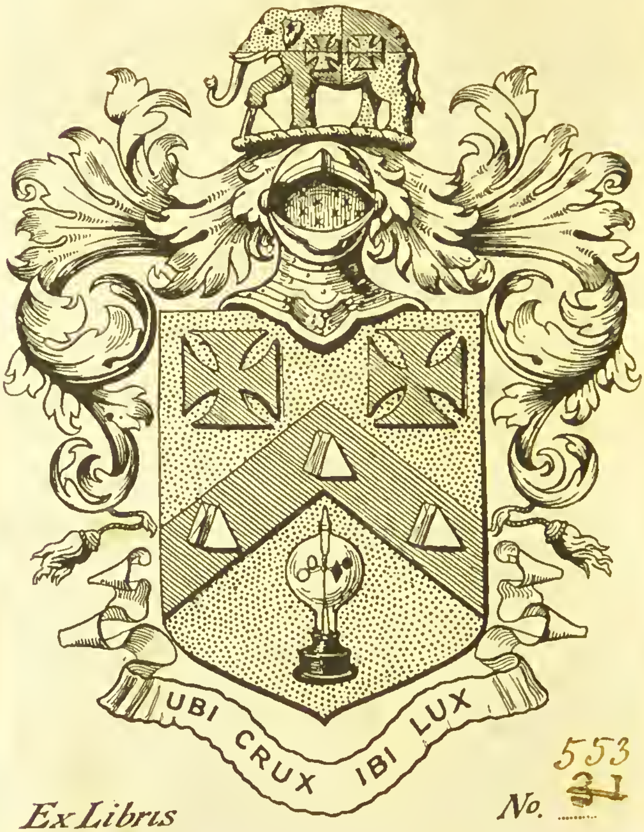
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Prof: W. Crookes F.R.S.
with kind regards
from the author.

COSMIC EVOLUTION.

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COSMIC EVOLUTION

BEING

SPECULATIONS ON THE ORIGIN OF OUR ENVIRONMENT

BY

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COSMIC EVOLUTION.

INTRODUCTION.

The idea marked out in this book is an extension of a scheme of evolution first put forward in a small pamphlet issued about a year ago.

Crudely stated, the general principle, on behalf of which arguments will be adduced, is, as follows:—"All the bodies at present existent in the Universe have, by a gradual evolution, or differentiation under a fixed law acting during varying conditions, been wrought from one primordial form of matter. This form originally existed at a tremendously high temperature, and was endowed with far greater chemical activity than any of its numerous descendants. The evolution

was attended with a gradual loss of heat, increase of density, and diminution of chemical activity."

If this principle is true, there will seem to be an unbroken connection between the two branches of Inorganic and Organic Evolution;—the latter would be, as it were, a new graft on the dying trunk of the older growth, and it might almost be said that "the chemical evolution proceeded till it finally induced an environment wherein favourable forms were matured into Life."

The very earliest and simplest impressions the human mind receives are the sense-pictures of the outer world. Gradually it is found that these sense-pictures are continually altering and being succeeded by others; in other words, that what we know as *change* is going on. This "change" is found by experience to be, as far as we know, constant, and without cessation; in

fact, it is the first law which we perceive in our world, and it seems a perpetual one. Time is only the order of change, and so, in a sense, its history; if change were to cease, then would time exist no longer; such a consummation is beyond the sublimest dreams of our imagination, which reared in change, knows but of change, and fails utterly to picture a changeless universe. This Change is the dominant law of the environment to which we are born; nothing escapes it; all are subject to it; indeed the sum and end of our knowledge is only to be able to forecast the directions in which its movements take place. Progress is but its path, Evolution its method of working; all mankind's grandest discoveries are but the sub-laws of its interaction.

Strictly speaking, each change seems to be merely the effort of Nature to adapt herself to the new conditions brought about

by antecedent changes. Everywhere, each body is modified to suit the environment; the existence of every body, animate or inanimate, depends entirely on its surroundings; modify these sufficiently, and, in the case of the animate, the organism perishes, or is modified also; in the inanimate, the action is direct;—alteration of chemical constitution keeps pace with the change of environment.

How change first originated we know not; but this we do know, that change exists; and, moreover, that each change, by slightly altering the general environment, directly begets others. Evidently here is a law pervading all nature; could we only discover the means and direction of its working, what a glorious insight into the whole mechanism of the universe might be ours!

When any change takes place the various

bodies influenced by the alteration of conditions are variously affected. Some, perhaps, are unaltered, some slightly changed, and others again so disturbed that they, in anything approaching their original condition, exist no longer. Hence there will be a tendency for the body most suited to, or rather (as the effect is a negative one) least detrimentally affected by, the surroundings to persist. In other words, in the Inorganic world around us there is continually taking place a destruction of the unfit, analogous to that taking place amongst living forms.

The problem, then, is to find out which are the fit, and the unfit, and to discover the history of the changes which led to the survival of the former.

In my attempt to work this out I am quite aware I have adduced no new facts, but my hope is that I may have succeeded in establishing a connection between well-

known facts that has hitherto been overlooked. A good deal of repetition has been necessary in order to clearly show the various connections between different points in the argument, and to lay its scheme, as a whole, fairly before the reader. On the other hand, however, the subject has been condensed as far as possible by omitting details and issues not immediately relevant, in order to make the scheme as concise and little tedious as possible.

A short epitome of the chief laws and theories bearing on the subject is given in an appendix.

CHAPTER I.

THE CHEMICAL ASPECT.

It has been found by experiment that all the substances with which we are acquainted in Nature are capable of more or less complete modifications according to the immediate set of chemical conditions with which we surround them. It has been found that if we alter the chemical, or even in many cases, the physical environment, the character of the body completely changes; all our important chemical and metallurgical processes depend on this fact. It has also been found that all the wondrously dissimilar substances we see around us, can, by localising sufficiently potent surroundings, be split up into one or more of a set

of about seventy substances of which the Earth seems to have been built. These seventy or so substances, in consequence of their having been supposed to be irreducible and ultimate forms of matter, are called "elements."

The formation of any new compound takes place in consequence of the greater affinity of its constituents for each other, than for the constituents of the older body, or bodies, of which they originally formed part. In other words, bodies whose constituents have little affinity for each other tend to be broken up, and those compounded with strong affinities to persist. Thus it will be seen that there will be a tendency among bodies compounded of strong affinities to accumulate on the Earth's surface, and of bodies made up of weak affinities to disappear.

But it may so happen that bodies with

very strong affinities indeed for each other, may have even stronger ones for other bodies, so that their compound may have less chance of persisting than a less strongly held together body with weaker elemental affinities. Thus, it follows that it is the body *which is most inert, as a whole,* or which is least likely to be decomposed or acted on by surrounding bodies, that will survive. Also, that the bodies which are least inert will gradually tend to disappear, and, unless continually in course of creation, will in time vanish altogether from the globe. Now it will be clear that owing to the multitudinous actions and re-actions which take place on such a body as the Earth under unsettled conditions, that in any *limited* period of time the effect will be inappreciably small. Still it can hardly be doubted that there must be a general tendency for the survival of the more inert

form, the effect of which, however, would only be appreciably developed in the course of enormous lapses of time. Whatever the conditions ruling may be, it will be seen that bodies *inert* under these conditions will tend to accumulate, while the more active bodies will be combined, and re-combined, till they are effaced in a more complex, but more inert, form.

Thus, as change gradually goes on, the more active bodies will be gradually united together, till their more energetic properties are mutually satisfied, and an inert body is the result. Now, looking at the past history of the globe as shown by the study of geology, it will be seen that for enormous periods of time the conditions have been (chemically speaking) very little changed, for though the temperature or even the volcanic activity may have varied so as seriously to influence living organisms, the

differences have never been so marked as to affect in any considerable degree the chemical condition of the globe. Therefore it may fairly be assumed that the process of gradual "survival of the most inert" has been going on from the earliest geological ages under what are practically the same conditions. Of course the gradual and continual formation of inert bodies would be continually reacting on the conditions, and tending to retard the speed of the progress. Now, if the course of time has been marked by the accumulation of the more inert substances, as here supposed, it will follow that we ought to expect the Earth as a whole to be more quiescent now than it was in times past, and that it will be more quiescent in times future than even it is now. And, as far as the past goes, this is what the evidence bears out, only the extremely gradual nature of the process has occupied incalculable

æons of time. Things must have been more lively, chemically speaking, in the Archæan period than now. A deliberate and unbiassed consideration of the general changes going on around us on the Earth, ought, if there is any truth in this "survival of the most inert," to advance a mass of evidence, favourable as a whole, but with many local, or even individual, cases of retrogression. Surely it does. Slowly, but constantly, the oxygen of the air tends to become fettered. Round about centres of volcanic activity, earlier and more active forms are indeed re-created, only, however, to be gradually merged in surrounding forms. In Nature's vast laboratory, as in our own small experimental ones, there is a constant tendency for barium salts to form sulphates; magnesium and aluminium salts, oxides and silicates; silver salts, chlorides; lead salts, sulphides; etc. The stable or

inert salt, when formed, remains—except under exceptional circumstances; but any other salt, though millions of such are continually in course of formation, is broken up sooner or later by contact with some unfavourable environment.

In using the word "inert" it is meant that a body is inert which is unaffected by changes of its immediate set of chemical conditions. Bodies which are inert to one environment may be very unstable with another. Consequently bodies which may appear to be elements under one, or even many environments, may be easily broken up when the conditions are unfavourably altered. Many bodies known to be compounds (such as lime, baryta, etc.) will defy all sorts of powerful environments, and only yield at last to perhaps one or two special sets of surroundings. This, though not of course a proof that there may not be one,

or even more, true elements capable of withstanding every possible environment, is strong proof presumptive that many, if not all, the so-called "elements" are elemental only inasmuch as we have not yet been able to isolate a sufficiently powerful set of conditions.

Every chemical body is "elemental" to some set of conditions, or it could not exist, and an element *may* only be a body stable under more extreme conditions than usual.

It has been seen that in the course of ages the more active bodies were obliterated in inert compounds; in other words, that at an earlier time there were many more active bodies in the composition of the planet than there are now. These more active bodies having afterwards become united into inert bodies must have been more simple or "elemental" (if such a term may be used) than they. Also, it is certain

that an inert body formed at a late period in the Earth's history, must be usually more complex than one of earlier birth. The latter was formed directly from the extremely active bodies of the older period, while the former was only produced by the combination of bodies, active certainly, but probably themselves the result of many unsuccessful combinations of the active bodies of period number one. Hence it will seem that as time goes on there will be a constant tendency of the bodies formed as the result of the changes in Nature to be of more complex constitution, and consequently of *greater atomic weight.*

It is assumed by chemists that the reason why substances combine in definite ratios is that the masses of the molecules of the substances are in the ratio of their chemical equivalents; in other words, the higher the chemical equivalent, the heavier, denser, and

more complex the molecule. This complexity has been owing to the continual chemical combination that has taken place under the guidance of the law of the "survival of the most inert," all combination being the action produced by the coalescence of the atoms of the molecules. For by the law of Avogadro there are in an equal bulk of all gases under similar conditions an equal number of molecules; the masses of the molecules, therefore, are in the same ratio as the density of the gases to which they belong. And as the molecules of all gaseous bodies are of the same size, it follows that in the denser molecule (belonging to the body with the higher atomic weight) more matter is compressed into the same space. This is clearly seen, for instance, in the combination of two volumes of hydrogen with one volume of oxygen yielding two volumes only of water-vapour, or steam.

Now in the groups of the elements the most active are usually those with the lowest atomic weight, and *vice versâ*, (*e g.*, the Halogens). This is exactly what we should expect, for, in accordance with our theory, in the groups of the elements those with the lowest atomic weight must have been formed first, and those with the highest last. Each group would then probably be parallel to that of any Organic series (such as the Paraffins, Olefines, etc.), in being M_n R_n plus the progression of the series. In the evolution, the bodies with the lowest atomic weight would be formed first, and some, being stable to the conditions then ruling, would persist, while a multitude of more active bodies under the more excited conditions then in force (consequent on the chemistry of Nature being less inert than now) would be quickly obliterated in new bodies which would in turn react to form a

new environment, and so in the slow elapse of time things would gradually settle down. The bodies with the higher atomic weights being formed under conditions of greater chemical lethargy, would tend each to be more inert than its predecessors of the same series.

It is obvious that if this is really what has occurred in the development of chemical compounds there will be greater gaps in the amounts of the atomic weights of the later formed elements than in those of the earlier formed ones;—the bodies of which the later forms were compounded were themselves possessed of considerable atomic weight, whereas the earlier forms, compounded from comparatively simple constituents, approximated more closely in atomic weight. This is just what will be found on looking over a table of atomic weights—the gaps increase with the atomicity.

As a general rule, it is certain that the elements with the lower atomic weights are far more plentiful, and more widely distributed on that portion of the Earth of which we have any knowledge, than those with the higher atomicities, which are, speaking broadly, local, and comparatively rare. Whether this is so throughout the great mass of the Earth, or whether it is merely the case in the solidified crust, we have no means of knowing. At any rate any speculation that might be based on this fact would be valueless, as it would be impossible to say whether the earlier formed bodies—formed from more plentiful materials, but subjected for a far longer time to changing environments—would be likely to be more numerous, or the later substances formed only from the *débris* of the others' contemporaries, but subjected to fewer trials from changing conditions. The

fact is probably significant, though its meaning is at present hidden from us.

If the law be true that a gradual tendency towards inertness is, and has been, continually taking place, it follows as a necessary corollary that the Past of the Universe must have been a time of vast chemical activity—of activity so vast that at one time our planet could not have existed as such, but must have been gaseously dissipated in space. For it seems certain that the chemical activity of the element, or elements of that time, must have been greatly beyond that of any present existing chemical substance. What then can have been the cause which led to the chaining of this vast activity by the formation of inert substances in the way we have seen? There can have been but one that we know of—loss of heat. This it is then which must have been the cause and guiding factor of that change

which has progressed on the lines of the survival of the most inert. The process by which the gradual formation of substances capable of continued existence under the violently fluctuating conditions took place, and the consequent reaction on the conditions, is far too intricate to be followed. How the original atom was formed, by what process of granulation it grew from the formless sameness of primordial matter, we can never tell. All speculation is baseless, the subject is too far beyond our ken; we must suppose as a starting point atoms to have been formed in all parts of space, which, having gravitated together, by their continual impact under the high velocities born of enormous distances, generated immense heat.

Then, for the sake of a general sketch, let us suppose a sub-elementary body at a high temperature with a tendency to com-

bine with itself on any change in the environment. This, let us imagine as an huge vapourous fiery ball poised in the midst of infinite space. Radiation would take place, and gradually cause a slight loss of heat and inequality of temperature; intercombination would thereupon ensue, accompanied, probably, by an evolution of heat which would break up the newly formed compound. The ever recurring loss of heat by radiation would gradually renew the conditions, and so reform the compound. More heat would again be given out by the renewed combination, and the action and reaction would ever more quickly recur till the body proved able to resist the temperature plus the accession due to its own formation. Thus, with radiation ceaselessly taking place, action and reaction would steadily continue, until, amidst the turmoil, bodies inert to the conditions should be

formed, which would survive till the formation of environments with which they were incompatible.

Gravitation in the mass—as has been proved—would have led to the formation of a multitude of heated spheres.

During the astral development, chemical evolution would be still proceeding. Any inter-combination would slightly alter the environment, when an action and reaction would be set up, such bodies as resisted the conditions remaining, and, by being put outside the sphere of action, causing the reaction. If, as seems probable, the process should have been gradual, and without breaks, all the intermediate unstable links would have been incorporated into new bodies, leaving only the more stable substances to last on; and, as conditions changed, the older and simpler body would have had less and less chance of existing,

till only the most inert substances would have been able to resist the enormous alteration of conditions up till the present day. This would sufficiently account for our difficulty in reading the cypher of Mendeljeff's law, when so many parts of its narrative are absent.

As the cosmic material in the midst of its chemical development became separated into different, and almost independent astral bodies, the progress of the evolution in each must have become tinged with its individual environment. Small spheres would have cooled quickest, there the process was most rapid; large spheres with their huge stores of chemical heat would have hardly suffered the evolution to proceed at all.*

Now if this theory of the survival of the most inert be true, and if it has taken place

* In many cases this seems in doubtful accord with spectroscopic observation.

in the manner sketched out, it is evident that the body which has undergone most chemical combinations, will be the body last formed—the body formed from a host of chemical failures, and of a highly complex molecule. In that body each re-combination of the original primal sub-elementary atom has been attended by the evolution of heat. Consequently, the later formed body with the complex molecule has lost more heat than the earlier formed body of more simple molecular construction. Now it has been shown by the experiments of Messrs. Dulong, Despretz, Hess, etc.,* that a body emits just the same number of units of heat if directly combined with another to its full extent as it does if combined with it by two or more intermediate stages: *e.g.*, carbon in burning to carbonic acid gives out the same quantity of heat as the same

* Page 408, Ganot's "Physics."

weight of carbon first burnt to carbonic oxide, and then the resultant carbonic oxide burnt to CO_2. Therefore it would seem that the amount of heat which has been given out by a body in the course of its formation depends directly on the complexity of its molecule, that is to say, that the amount of heat evolved from any bodies in the course of their development will be directly proportional to their atomic weights.

It is known that the atomic weight of every element is inversely proportional to its specific heat, or, in other words, that the atomic weight of the body, multiplied by its specific heat, is a constant number. This law also holds true among compounds of similar constitutions. What is known as the atomic weight of an element would, however, really be the weight of a molecule of its more primitive constituents.

Now starting with the original primitive

molecule--formed how we know not—let us see how the course of the evolution of matter may be traced. In the first place we may assume that the body composed of those molecules existed in a gaseous state: liquids and solids belong to far later epochs in the history of evolution. It is known that with all gaseous bodies under similar conditions of temperature and pressure—however different may be their densities and chemical properties—equal volumes of any of them always contain an equal number of molecules.* In other words, under similar conditions the size of the molecules of all bodies in their gaseous state is the same. Heat is supposed to be molecular vibration. Now under extreme vibration matter tends to be torn asunder, and while the whole universe was in a state of frenzied movement, only the simplest, and most tenuous form of

* "Law of Avogadro."

matter, could have existed. As heat was lost, and the vibration grew slacker, the primitive molecule proceeded on that course of natural selection which we have termed the "survival of the most inert." This course proceeded by the chemical coalescence of the molecules, so that the volume of the matter gradually decreased, while its density increased. The manner in which this took place may be exemplified experimentally at the present day: to give an instance, three volumes of hydrogen and one volume of nitrogen, united chemically, produce two volumes of ammonia; in other words, the molecules contained in four volumes of gas have been condensed into the number capable of being contained in two volumes, with, of course, a corresponding increase in their density.*

By stages similar to this must the mole-

* "Law of Gay-Lussac."

cule have progressed on its path of evolution, and it is easy to see that, while the more tenuous might coalesce easily into a condensed molecule, the denser the molecules became the more difficult would this tend to become, and the slower would evolution proceed. This is a simple explanation why chemical bodies as a rule should be more inert as their atomic weight is heavier, and explains why in every particular group each successive member is more lethargic than its predecessor. At the same time the chemical union of the more advanced molecules would depend largely on their internal structure, and full play would be given to the struggle for survival between the fit and the unfit, the inert and the unstable; all the while, however, the gradual survival of the denser, and more inert bodies, would be continually slowing down the rate of evolution, and confining the scope of its working to narrower

and narrower limits. For, as each inert body, formed from the *débris* of its active and unstable predecessors, in turn separated out, less and less material remained available that had not been already appropriated for the formation of some inert molecule.*

Each coalescence of the molecules in chemical union was accompanied by a marked increase in their vibrations, the increase being often so strong as to cause dissociation and reform the original constituents; and it is only natural to suppose that the condensation† of the vibrations of two or more bodies into a body occupying a smaller space would be attended by intensification.

* Thus, it would almost seem that the earlier formed bodies with the lower atomic weights should theoretically be more plentiful than the later and denser ones. See page 19.

† Caused by the operation of "Gay-Lussac's Law."

With regard to the relations of the specific heat and atomic weight of bodies, a greater amount of heat has to be poured into the lighter body, and the activity of the lighter atoms has to be much increased, to give the same *vis viva* as the less rapid vibration of the heavier ones, because for bodies of unequal density to be of the same temperature, the smaller mass of the atoms of the lighter body has to be compensated by their greater velocity.

The theory of the gradual building up of the molecule according to our law, thus seems to fit very well with the almost certain fact of the gradual loss of heat in the universe. From this it should follow that the degree to which this "evolution of the most inert" in any one cosmic body has taken place, should, to a certain extent, depend on the size of that body, as the small would have lost heat more quickly

than the large. At the same time it must be borne in mind that after the separation of the (as it were) fermenting material into separate cosmic bodies and systems, the progress of the evolution would have become very markedly localised, and subjected to a more limited and individual environment. Hence, it is probable that in the hotter stars at the present day, "elements" of high atomic weight have not yet been formed; at any rate such highly developed compounds as are present on our earth could not of course exist.

More than one argument as we have seen supports the theory that this Inorganic Evolution has taken place;—the analogy of present chemical action and terrestrial tendencies;—the shape and character of the globe, with its oxidising crust and incessant chemical reactions;—the turmoil in the sun;—and, above all, the results of spec-

trum analysis in the stars and that body. This analysis shows, as the result of long observation, that each increase of solar activity is followed by the appearance of unknown lines in the spectrum. At, and slightly after, each sun spot minimum, the lines seen are chiefly the known lines of various metals; while at, and just after, the maxima, the lines are nearly all of unknown origin. Clearly, at the high temperature, the disappearing elements (among which, notably Iron) have been broken up, and the spectra then seen are those of their constituents. The action and reaction before spoken of, is thus seen taking place in a cosmic body before our own eyes.* Even when, at a

* And from the disappearance and reappearance of the Iron spectrum it would seem as if the Sun is just at the age of evolution when that element is separating out from the cooling mass.

comparatively low solar temperature, we recognise spectra identical with those of terrestrial "elements" under the heat of the arc or the induction spark, it is perfectly possible that in both cases the substances may be dissociated by the high temperature, and that the spectra seen may be really those of their constituents. If, however, the seventy or so bodies which have hitherto successfully withstood all the environments with which chemists have surrounded them, are really elementary and distinct forms of matter, any theory of chemical evolution must of course fall to the ground. But besides the reasons already adduced, and the fact that all bodies are elementary to some set of conditions, and many to very extreme ones, there is another extremely cogent band of facts that believers in the elements as ulterior forms of matter must face. Soda; Potash; Oxide of Vanadium;

and, until quite recently, Didymium; all did service as elements. Yttrium has fallen to a process, the carrying out of which might well have put Job to shame; and above all, Prof. Nordenskjöld has found that three separate bodies occur in Nature, not only always together, but always mixed in the same proportions. These three bodies are Yttria, Erbia, and Ytterbia, and their mixture (which of course is an oxide) possesses the constant atomic weight characteristic of the compounds of an element.

If chemists can be deceived as to the elementary nature of one substance, it seems probable that time may enlighten us as to the compound nature of others; at any rate, when the pro's and con's come to be balanced, the most that any defender of a conventional element can say, is, "no one has yet decomposed it."

This theory of the descent of matter after

a manner strictly analogous to that of living forms runs counter to no known chemical laws. The evidences of probability in its favour have been stated, the only evidence contra is that up to the present no conclusive proof of its truth has been forthcoming. Plausible reasons have, however, been shown to account for the increase of atomic weights being accompanied by a corresponding chemical sluggishness; and, more important still, the question of specific heat in its relation to atomic weight has been shown to be explicable on this theory. How the reiteration of the elements in the cycle of seven, and the ebb and flow of the atomicities came to pass, how the alternations of Para- and Dia-Magnetism, and all the other wonderful and most pregnant extensions and amplifications of Newland's law were brought about, at present are the darkest secrets.*

* A semi-plausible theory of the law of Octaves is given on pages 70 to 76.

Looking at the analogies shown in the various series of organic chemistry, it seems probable that the differences and relations of the so-called "elements" may be due to the way in which the sub-elementary matter is arranged in their molecules. Under this supposition, the differences between the seven recurring classes of elements in Newland's law would be due to differences of structure in the heart of the molecule; while the altered, but still somewhat similar, character of members of the same group, would be due to substitution changes round the fringe.

The chemical properties of a body (according to our theory) depend on the density, complexity, and internal structure of its molecule; consequently, increase in weight and complexity, unattended by alteration in the internal structure, would give a similar, but rather more lethargic,

and less active compound. Alteration in the general plan of internal structure, on the other hand, would change the character of the body altogether. Possibly careful and detailed study of the molecular constitution of organic bodies, and their relations, might throw light on these questions; the whole problem, however, is most complex, for the sub-elementary unit itself is hypothetical, and the atomic weights on which we base our conclusions are not absolute numbers, but numbers expressive of weight relatively to that property in one of themselves.

Should the chemistry of high temperatures become better known to us, and their conditions be made more easy of attainment, and more amenable to control, it is probable that the genealogy of the "elements" will be as fully understood by future generations as that of the Benzene compounds is now.

Possibly the cases may even prove somewhat analogous, a heptad sub-element in the former case acting similarly to the tetrad carbon.

With any marked change of conditions some of the earlier chemical forms may become temporarily apparent, as it seems possible they do when the spectrum of an element differs considerably at different temperatures.* This may be due to the temporary decomposition (partial or otherwise) of the element. Again, when any lines correspond in the spectra of any two

* For instance, sulphur vapour shows by absorption a continuous spectrum up to 1000°, when a spectrum of bands ensues. When a strong electric spark is passed through the vapour a bright line spectrum is seen. These successive results are currently believed to be due first to the splitting up of the complex molecule to S_2, secondly, to the decomposition of S_2 into atoms.

elements subjected to the heat of the electric arc, it is probable that the correspondence is due to the decomposition of each, and the appearance of a mutual constituent elementary to the conditions imposed.

To summarise this chapter, it is evident that changes must always have been taking place in the past, and from what we know of chemical bodies now, it is certain that change of conditions must have modified at least some of them. Since it is practically certain that there was change, and always has been change, continuously going on in a greater or less degree from the dim beginning till now, and since it is equally certain that that change must have modified in some manner the matter then existing, the plea herein put forward is that there is good reason to suppose that the process was gradual, continuous, and in accordance with a well defined law. This law was the "sur-

vival of the most inert,"—another form of "natural selection." Those bodies formed in a manner to best resist the changes of conditions—in the same way that Corals, Tree-Ferns, and the earlier forms of Life, have lived on into our own times—survived, while those which adapted themselves (so to speak) in their descendants, while perishing themselves, continually built up a more complex molecule, and, in that way, kept pace with, and conformed to, the new environments.

The rate of change was much more rapid at first, and, through the gradual survival of more inert forms, slowed down, till at the present time it is, comparatively speaking, almost at a standstill. So surely, and so thoroughly, has this process gone on, that the environment has grown calmer and calmer, till a state of things has supervened under which ordinarily unstable and deli-

cately organised bodies have been able to exist. It was when this state of physical calm was fairly matured, that the forces acting in the Evolution of Living Forms were first able to come into play.

CHAPTER II.

The Organic Aspect.

Up till this period in the course of evolution, cooling suns and systems, with their attendant chemical changes of constitution, alone built up the frame of Nature. In the fiery epoch of the past for countless æons the universe had existed as a gaseous tornado of fire. Gradually, gradually, its energies had become condensed and localised; astral bodies had formed; and heat had been lost, till this little rejected sputter, Earth, had cooled to a temperature not very different from that it at present bears:—save that probably its internal heat was greater, while its received heat, on account of a denser and more aqueous atmosphere, possibly was

the same, or less. On this trivial planet, under the conditions then ruling, a new and original force came into play, one so different in its tendencies, and so unlike in its action, to any of the previously existing forces of Nature, that its occurrence by natural causes, seems almost—if one may so put it—supernatural.

This force was Life. Ever since its first manifestation, while Inorganic Evolution has proceeded contemporaneously with it, though in a milder and more subdued form, its power and scope of working have steadily increased. How it arose we know not; whether it was latent from the beginning, and, oppressed hitherto by the dominant environments, only awaited a period of quiescence to come into operation, or whether it was induced by a special act of Creation we cannot tell. All we can do is to trace it back, and back, to the earliest and lowest

forms as they now exist on the Earth. By so doing we find a great approximation between its two great branches, Animal and Vegetable Life; these in many cases approximating so closely as to be almost indistinguishable. The further back we proceed with this tracing, the less strongly concentrated this force of Life is. In the earliest forms there is a great outward similarity to the Inorganic, the sole difference consisting in the possession by the one of this vital force,—a force which confers individualism on an aggregation of matter, and holds its constituents together in spite of contrary chemical tendencies. In the ascending scale of life this force becomes, as it were, more concentrated; the lower forms are, as a rule, more tenacious of life, and more capable of retaining it under extreme environments; while as we ascend the series, the tension of the force increases

with its intensity, and any severe disturbance of the normal conditions is attended by the death of the organism and release of the force.

It is remarkable, as bearing on the "survival of the most inert" in Inorganic nature, that with all *Life* the tendency seems to be to eliminate the comparatively inert lower orders, and to extend and multiply the delicately balanced organisms. It is also noteworthy that the force of Life appears to act in opposition to the chemical forces, binding together in the body under its control all sorts of bodies in compounds of wonderfully unstable equilibrium. It is also capable of breaking up an ordinarily inert body, and of, perhaps, re-uniting its constituents in some otherwise utterly impossible combinations. In fact, in the domain under its immediate control it seems, so to speak, as if the chemical forces were

modified to conform to the rules of the establishment. When, however, the extraordinary force is dissipated, and death is said to occur, the law of the survival of the most inert once more asserts itself, and the unstable components of the dead frame are broken up into substances better able to resist the action of the environment.

From the standpoint of universal evolution it is evident that the environment is the grand controlling factor. It is merely as a consequence of the thorough survival of inert chemical forms that a state of such quiescence has supervened as to admit of a further selection among living forms by means of an inter-racial contest. The whole "survival of the fittest" in the struggle for life is therefore merely a sub-law, owing its existence to the thorough action of the original grand law, "the survival of the most inert." And it is a proof of the

thoroughness with which chemical evolution has done its work, that in Organic evolution the physical environment is almost ignored, nearly all modification proceeding from the inter-racial struggle for life. If the chemical, and so physical, environment were a violent one, all modifications of living forms would take place to produce a form capable of existing under extreme conditions; the inter-racial selection would be lost sight of in the more important and direct action of the environment. Conversely, the more same the environment, the more untrammelled inter-racial selection would act.

It is possible that some slight trace of this may remain in the well authenticated tendency of living organisms to vary: in the early times, when the geological forces were more active, that stock had a tendency to survive whose members varied most. Consequently the tendency, being beneficial

to the species, was perpetuated. Contrariwise, is it not possible that heredity itself may be due to the fact that the parent form having proved itself fitted to the environment (or to the struggle for existence) those of its progeny that most resembled the parent would be the more likoly to prove fitted also, and so in their turn survive?* And may not the blending of these two—the tendency to inherit, and the tendency to vary—be due to this blending being the ratio of modification to stereotyped transmission, which most coincided in past times with the average change of environment?

Again, assuming these speculations to be true, may it not be, that owing to the forces of the Earth having been most active in the earliest period of Life's evolution, the proportion of variation to heredity was con-

* Independently of the original reproduction by fission.

siderably greater in those earlier forms of Life than it now is in their present descendants. Under these circumstances evolution would have proceeded faster than now; and—if the tendency to variation be indeed dying out owing to the Earth's physical quiescence—this may reduce in a great measure the time necessary to be allotted for Evolution, while at the same time explaining the apparent non-variation of Man from the time of the Pyramids. If this view of the case be the true one, it will be evident that in the higher forms heredity will have a much stronger influence than in the lower, and that in Man, for instance, the reproduction of the parent type would be much more exact than in the lower animals, and this notwithstanding a greater complexity of form.*

* I do not know how far this is supported by evidence.

It should be noted that it is borne out thoroughly by Palæontological evidence that a family succumbing either to slow alteration of the environment, or to inter-racial competition, always varies violently during the process. This would show that when the struggle for existence grew keener, and more oppressive, it would have increased the tendency to variation, and surely, when every form was presumably less fitted than those now existing to meet the struggle, the variations must have been faster, and more abrupt, than now.

This subject has only been here briefly sketched in its general outlines, it is capable of considerable expansions with very interesting developments.

It is often accepted as strong evidence that living matter could never have been formed naturally from Inorganic Matter, that spontaneous generation, as people are

pleased to call it, does not take place at the present day. Surely, it is said, if dead matter ever gave rise to living, it ought still to continue to do so; whereas we find that the most likely compounds, if only shut carefully off from the almost omnipresent germ, never betray any acquirement of even the lowest degree of life. Yet the fact that we can in no way now produce life from inorganic forms, *because we cannot reproduce the conditions*, is in itself really a striking correlative proof of the correctness of the evolution theory. Those conditions which gave rise to the result so many milliards of years ago, cannot be reproduced; and could they, we should still, in all probability, be without the parent form on which to work. No sane man would attempt, by manipulation and modification of the environment, to obtain Greyhounds by breeding from a Fox stock, and yet no one that has kept himself

abreast of modern thought will doubt their procedure from a common ancestor. Favourable conditions acting for a protracted period produced the divergence we now see. So with Life and the Inorganic parent bodies; both, probably, and certainly the former, have suffered multitudes of modifications since a propitious environment, acting on some matter then existing, gave birth to the earlier and lower members of the Organic branch.

Again, in the Inorganic world no one can transmute Lead into Gold for a similar reason: both were formed at different epochs from the less inert bodies then existing by the action of different environments on different forms: mutual transmutation is impossible.

Should it, however, prove possible in the future from Inorganic bodies to produce living forms, an undoubtedly mortal blow

would be struck at the evolution doctrine as it now stands. We could never transform one species into another, yet the gap between living and inorganic substances should be incomparably wider than that between any known species, on account of the vastly greater time that has elapsed since the separation took place; all time being accompanied by change, all change by a widening of the course of evolution.

A Moneron does not seem a highly developed organism compared with Man. Indeed, to a casual observer, the difference between one, and man, would appear to be immensely greater than that between one, and a mass of gelatinous silica, or any colloid body. How much more closely must the lowest forms of life have approximated to inorganic compounds at a time, say, when *Eozöon Canadiensis* represented the highest effort of evolution. Those forms are gone,

obliterated by the strifes of ages; all record of them has mouldered from the rocks of the past; they served their purpose, filled their allotted station, and passed away. Without them, Life, as we now know it, could not have been formed; yet they exist but as shadows,—dreams in the mind of Man. Those missing links, what a history is theirs: birth, death, and oblivion, succeeding in turn, till their parentage is a guess, their existence but conjecture, and their habits and form a blank! Deep on in the roll of the ages, even so it may happen to Man!

It has been seen that in chemical nature the unfitted body is engulphed in the frame of the more inert compound, the evolution as it proceeds living upon its failures; this is even more clearly seen in the case of Life. There, the highest organism preys on all beneath it, the next

highest on those beneath them, and so on down the course of evolution, the higher form preying on the lower, and the lower acting as a connecting reservoir for assimilating and rendering serviceable the crude nutritive properties contained in the lowest. Of course there are very many exceptions to the rule that the lowest are the victims, and the highest the assimilators; indeed, the sequence tends to move in a cycle, the highest after death serving as food for the very lowest. It is only vegetal life that can subsist without preying on some other form of life; all animals are predative, if they do not prey on each other they devour living vegetable matter.

Nature wastes no materials, all is used over and over again; the decease of one form is the advantage of another, and what truly wonderful ingenuity she displays in weaving and working out from compara-

tively the same materials, the innumerable variety of her forms.

The original form of life seems to have been, as far as we can judge, of the nature of a simple cell; numbers of these, reproduced by fission, probably agglomerated round the parent form. Of such agglomerations, those built in a particular manner proved more successful in preserving the well-being of the community, till in the course of time such clusters began to take upon themselves well-defined forms. After a time, so necessary did this formation become, that the good of the individual cell became merged in, and finally subordinate to, the good of the commonwealth; and, at the same period, different cells began to be differently modified according to the position they held in the cluster. Traces of this cell descent are present in all life; though, in animal life more especially, the cell itself is

lost sight of in the distinct individuality of the community as a whole. In vegetal life the cell retains more of its own separate character; a tree, for instance, seeming almost as much a congery of cells, as one thing, a tree, while any animal always seems more the one independent being than a heterogenous compound of very differentiated cells. After all, however, the plant organisation is but a cell cluster rooted to the ground for the better attainment of its nourishment; whereas an animal is a cell cluster that, disdaining to be ever stationary, has cast away its anchor and acquired powers of movement as a means of preying upon its fettered and unprotected cousins.

The gradual approximation in character of the lower forms of animal and vegetal life, and the slow narrowing of the break of demarcation between living matter and the Inorganic, as we descend lower and

lower in the scale of life, have been already noted. The reason why these approximations should take place, unless they are relics of a time when each class blended imperceptibly into the other, is not so clear. It is a known fact in Evolution that the connecting links seldom survive long; the gaps between species tend to widen with time; fewer and fewer intermediate members are born, till the races become distinct. Were Life a supernatural, or extraneously imported force, there seems no reason why its intensity should not be as marked in the lowest as in the highest forms. All things considered, perhaps the nearest parallel we have in Nature to the force of Life is that force which determines crystalline structure. No doubt the two forces are not the same—that goes without saying—their results, and their fields of action, are totally different, yet their methods

of working, and even probably their origin, are very similar. Neither force would have been manifested had matter always remained in a hot and gaseous condition: from a parent stock both invariably produce new forms similar to the original ones. When the new form perishes, the force is apparently lost, but the materials may be absorbed to form a fresh individual, which, from the moment of its first formation, grows.

Let anyone watch the growth of the beautiful crystals of acetate of lead, and then the dull movements of an Amœba; it is the former that will seem inspired by the higher force.

If in conjunction with the crystallographic force we consider the force of electricity, there are few phenomena of life which one or the other cannot imitate. A recapitulation of their analogies would be tedious, and

appear a sophistical attempt to make the unlike appear like, in order to fit a preconceived idea; for it may be candidly admitted that no force, or forces, exactly similar to Life, are known in nature, *though one or two of them are not so utterly unlike as to render it necessary to postulate a supernatural interference with the course of Nature to account for its occurrence.*

With regard to consciousness, it appears as if this were an after-growth of life, for low down in the scale there seem to be forms endowed with a distinct individualism, yet utterly devoid of consciousness, though it should be borne in mind that with these, as indeed with non-living matter generally, it is not that *they* are not conscious, but that *we* are not conscious they are conscious.

Thus the consciousness of inorganic matter may be unnoticed, merely because it is of such a low order, and unaccompanied by

reflex action; but such a speculation is so vaguely metaphysical as to be valueless.

There is no need here to recapitulate the classic laws of organic evolution; they are so well known, and have been so thoroughly discussed, that every educated man has early formed his own opinion of their value.

The problem of social evolution has also received such attention that it has risen into a science by itself. In it we find a case in progress parallel to that in which evolution, first acting on the simple cell, afterwards acted on the cell-cluster for the benefit of its individual members, and on the members themselves for their mutual advantage. Here, evolution has so acted on Man that it tends to produce a form which will act, not for its own welfare alone, but for its welfare plus that of the community. Men aggregated for their mutual defence, and those tribes were most successful whose individuals

sank their selfish ends in the general well-being of the society. As it became necessary for the members not to be all individual warriors, but to follow different avocations for the mutual good, so grew up the higher forms of States—in the same way that the cells of the living organism became modified into epithelium cells, liver cells, bone cells, etc. In each case that mass succeeded best whose units by variety made the whole most self-sustaining. Consequently those wholes whose units were most widely differentiated were perpetuated in the struggle.

The human mind itself has been developed by evolution, and its method of working yet seems to bear traces of the process. Our only acquaintance with surroundings is derived through the medium of our senses, and the most simple form of knowledge is that of a direct sense-picture, or sensation. Custom from birth, and long heredity, have

endowed these sensations with an absolute external existence; it is by the comparison of these sense-transmissions that the edifice of human knowledge is built up. There seem, however, to be two ways of determining the sequence of events from sense-pictures—Intuition and Reason. Intuition may be taken to be the instinct of the human animal; its employment by the individual is far rarer than the more ordinary method of analysis, Reason, and its use takes place in a great measure unconsciously. Intuition is said to be surer than Reason; this is probably because Intuition is the abandoning of oneself to the unconscious sway of hereditary knowledge, a knowledge which having proved of service to individuals in the past, has been handed down, and improved upon by selection, till it now, unconsciously, and without any effort on the part of the individual, determines the course of

action in the present. Intuition most generally shows itself in emergencies with which, from their peculiarity, or suddenness, reason is unable to cope. Inspiration would almost seem to be derived from the same source, when the mind is allowed to float back on the stream of inner consciousness, thence deriving a purer and more certain strain of thought than could be derived from the mere analysis of passing facts. Intuition would be the true and useful residuum of the original knowledge, after the false had been weeded out through many generations. Each generation would be at the same time confirmatory, and purificatory; so that for subtlety, and condensed accuracy, thoughts obtained from this source would be greatly superior to the coarser and more disjointed thoughts obtained by individual reasoning from extraneous facts. This hereditary transmission of knowledge is a very in-

teresting subject; in it, apparently, lies the only hope of posterity to assimilate the enormous masses of scientific data that are being accumulated daily.

CHAPTER III.

The General Aspect.

If the vapour of the sub-elementary body, from which the solar system is here supposed to have been evolved, grew slowly cool, it will follow that after the formation of orbs, and their distribution in revolving systems, the smaller and more isolated bodies must in each case have tended to cool first. Hence the evolution in a small mass of the cosmic material will have been more rapid than that in a larger; so that we might expect to find fewer types of matter remaining there, with the gaps between them large and well-defined. In a bigger body that has retained its heat long, on the contrary, the action and reaction would have been so

constant, and gradual, that it is probable that at the final cooling a much longer and more closely connected list of "elements" might remain.

It is evident, with regard to our own solar system, that ere the decrease of volume consequent on chemical union took place, the mass of the sun must have occupied an immensely larger space than that where it now is.* We know that whatever number of volumes of the combining gases existed before each chemical union, two volumes, only, of each resultant compound were formed. So that at a period when all matter was gaseous, the shrinkage of the mass at each stage in the survival of the most inert must have been enormous. Might it not have been during such sudden contractions that the planets, as gaseous masses, or rings, were left behind in their orbits—possibly

* *Vide* "Nebular Theory."

each planet marking the formation of some inert compound?

What a wonderful vision of Nature might be based on such a belief! The furthest planets thrown off from the lightest materials of the periphery of a cooling sun; yet those lightest at each stage being denser, and so cooling to a denser orb!

By the comparatively small space that is occupied by the matter of the solar system now, compared with that gigantic void within the orbit of Neptune which it must have occupied in the past, it is certain that its condition must have undergone an enormous alteration. The Matter of that time must have been vastly more tenuous than at present. And can the change have been brought about by mechanical contraction alone? It seems more than doubtful. That the matter composing the spheres of our system could ever have been merely vola-

tilised to the degree of tenuity necessary, seems incredible of belief. But if, superadded to the other physical forces, chemical forces were also in operation, the law of Gay-Lussac supplies a very probable explanation of what took place.

If the giant vapourous ball was composed of a material, or materials, of great tenuity and under high temperature, the contraction due to chemical union, acting along with the "survival of the most inert," would infallibly have produced a state of affairs similar to that now existing. Matter would have grown denser, and more differentiated; at nearly every union of the gaseous masses, contraction, with all its attendant train of consequences, would have taken place. There is a curious coincidence between this idea of cosmical evolution, and Newland's law of octaves.

Supposing the asteroids to represent one

large planet, there are, in all, nine planets, viz. (taking them in order of greatest distance from the sun) Neptune, Uranus, Saturn, Jupiter, the Asteroids, Mars, Earth, Venus, and Mercury. Now if the Sun's mass originally occupied all the space to the orbit of Neptune, and left the planets successively behind it at each great chemical collapse occasioned by the formation of a fresh inert body, it is obvious that when Neptune had been left behind, one inert body had been formed; when Uranus, two; when Saturn, three; and so on. When the collapse that led to the formation of the Earth took place, *seven* bodies had been so formed. Now after each planet was thrown off, the chemical evolution in that planet must have proceeded much faster than in the remaining solar mass, on account of the smaller size, and consequently quicker loss of heat of the planet. Also, being separated

from the parent mass, the evolution would have become distinctly local, and thus the survival of the most inert would have proceeded, using as material whatever bodies had been already formed in the planet at the time of its detachment from the parent solar mass. Consequently, from that time when the process grew comparatively hurried and local, we might expect all evolution to proceed by the modification of the early formed bodies that were present when separation took place. Thus, as seven bodies had been formed when Earth was left behind, we might naturally expect to find that the evolution proceeded by the modification of the seven types originally existing. *This would explain the reason of Newland's law,* but at the same time would necessitate supposing that in Mars evolution proceeded in cycles of six, in Venus of eight, and so on. As we have not only no evidence of this,

but as all other reasoning tends to lead us to believo that the chemical composition of tho planets is very similar, we can only look on this as a curious coincidence.

At the same time there is nothing inherently impossible in Mars being devoid of one-seventh part of the elements found on Earth, Jupiter of three-sevenths, and so on; but when it comes to Neptune devoid of six-sevenths, or with only one of the series present on Earth, improbability seems to verge very nearly on impossibility.

There is just a sufficient approximation to probability in this theory to invest it with a certain amount of interest, though it is not intended to be put forward seriously. The attendant Moons of the outer planets are a source of difficulty, also, that can scarcely be fairly reasoned away by putting them down to the effects of inter-planetal evolution after separation.

Nevertheless, part of this idea, probably, is true; namely, that the contraction of the nebulous mass as supposed by La Place, was greatly helped by the collapses caused by chemical combination, and it is probable that the rings from which the planets were subsequently formed, were each left behind at times of some great collapse. The formation of the rings seems much more easy of comprehension if the increase of centrifugal force* took place abruptly on sudden contraction, than if it took place in the gradual way of simple cooling supposed by La Place.

At each successive detachment of the mass from which a future planet was to be formed, the materials left behind must have been denser. The collapse that separated each from the parent mass must have increased the density of that remainder, so

* *Vide* "Nebular Theory."

that the matter left behind at each stage, and on which the chemical evolution of each planet had to take place, must have been in each case appreciably denser than in all earlier ones. Consequently we might expect to find the densities of the matter composing the resulting planets following a similar order.

The density of the planets compared with Earth's as unity is: Mercury, 1·12; Venus, 1·03; Earth, 1·00; Mars, ·70; Asteroids, —; Jupiter, ·24; Saturn, ·13*; Uranus, ·17; and Neptune, ·16.

If this theory were true, there would

* Saturn is thus the only exception. The density of the other planets is in the order of their nearness to the sun, the most distant being the least dense. In both Jupiter and Saturn the evolution seems to have proceeded very slowly, possibly on account of their great size. Their temperature, also, is still probably considerable.

probably be some connection between Bode's law and the unknown cypher running through the atomic weights in Mendeljeff's law.

If this general scheme of evolution be true, it must be true not only for our Earth, but for the whole solar system, and not only for the solar system but for the starry universe at large; in all, change must be taking place on the same general lines, modified as to details in each particular instance by the environment immediately around. Thus, the chemical evolution of matter has been responsible, in the first place, for star systems, formed, and separated from each other by the earliest unions of the original tenuous universal substance; later developments in each system gave birth in succession to the secondary suns, planets, and moons; till the survival of inert dense forms, and the solidification of the materials, rendered possible the existence of a body such as Earth. This

evolution is to be seen at various stages in the heavens; some typical of terrestrial periods long gone bye, others of those to come in the far future.

Of the time all this must have taken, we can form no conception. As has been said before, Time is but the history of change; and change has been going on from eternity, and must ever, it seems, in some form or another, continue. Man is but an offshoot of its course, permitted by its laws to note its working for a brief second in its career. His very mind is but the effect of its development; alas, for the impartiality of his judgment, he can never get free from its influence, and view things, as it were, from outside! So much are we the children of circumstances, that all our knowledge, all our world, is that of bodies in motion; what may happen when matter is at rest—if it be not a contradiction in terms—no one

can say. Truly Man is hopelessly situated; the further the ray of his intelligence would penetrate, the darker becomes the gloom !.

To Man, a finite being, it seems necessary that everything should have a beginning, and an end; what then, he would ask, is to be the end of evolution? Even so might the bubble on an eddy of a river seek to know where its flow would cease! Yet, from the fleeting glimpse we obtain, everything seems to point to a stato of quiescence,—a sort of realisation of the Buddhist Nirvana,—as being the end and ultimate goal of evolution. The main objection that has been taken to evolution, considered not only as the general scheme of Nature, but even as the particular instance of the development of the living organism, is the time it must have required for its working. If this question of time ran counter merely to the

after-all hypothetical laws of Evolution, and time could be proved by the positive teaching of facts to be of comparatively thinkable duration, hard though it might be from the conclusiveness of its reasoning to give up such an hypothesis as Evolution, no one would hesitate. But if this theory of the limitation of time—even though certain physicists should fancy that by abstract reasoning they have proved it—should be found to run counter, not only to a valuable working hypothesis, but to every known geological fact, and to all the teachings of Astronomy and Biology, there is no question which we ought to throw over.

It is probable, however, that when the objectors deny to the sun a birthday more than twenty million years distant—a period inadequate to account for the facts of terrestrial geology even—they have not taken into account the fact, that if chemical

evolution has taken place, as it must have, the more active bodies of earlier periods gave out vastly more heat on their union than do their more inert descendants of the present day. So that to work out the problem of the Sun's age at all from the heat capable of being evolved from its mass, some mathematical progression must be used, and not an ordinary rule of three formula.

The cause of the continuous emission of heat by the sun has been attributed to the shrinkage in its mass, which would almost seem an inversion of cause and effect. Would it not rather be the fact that shrinkage is only possible because of heat lost, and not that the shrinkage could of itself evolve heat. Under this view the shrinkage of the Sun's mass by so much would be proof positive that a corresponding quantity of heat had been evolved.

A new theory has been started lately that suns have been formed, not as we have supposed by a gradual process of chemical evolution from primitive matter, but by the collision of meteor swarms:—the impact of these bodies when travelling at high velocities being sufficient to produce the heat necessary to merge the solid meteoroids in a blazing sun. This theory really seems purely fanciful. To begin with, the size of a meteor swarm sufficient to produce a body even as large as our sun (or 316,000 times the mass of the earth) must have been so prodigious that the human mind can scarcely credit it ever existed. Again, the heat generated in this manner would be of the most evanescent character; there would be a brilliant flare up, and then, the source of energy not being continuous, the body would rapidly cool to a dead state. Having no proof whatever, or any indications of proof, that

suns* have been so formed, why should we imagine a purely hypothetical series of phenomena, the existence of which, if real, would be every whit as hard to explain as that of the sun we see? If these meteor-swarms existed, how were *they* formed? All the meteorites of which we have any knowledge possess a high chemical constitution, being formed of known terrestrial elements, of which the most prominent is Iron. Their shape and size are irregular in the extreme, and the balance of evidence would tend to show them to have been ejected from the Earth

* Despite sundry low temperature spectrum similarities, though it seems probable that the light of some of the temporary stars may have been due to collision of some sort. Yet even they, and also more especially variable stars, are explicable on the assumption that the sudden light is due to the formation of a solid inert body, the glow of the particles of which, previous to their redecomposition, causes the sudden flood of light.

at an early period of its career. That meteoroids exist, except where there is a central (presumably parent) body, we have no evidence whatever, except perhaps in the doubtful case of comets. It is even possible they may be the scattered remains of a rudimentary ring similar to that possessed by Saturn. To imagine the formation of suns by their agency seems an inversion as woeful as to imagine the formation of the Earth from pebbles. The meteorite is a body which bears in itself conclusive evidence of its fire manufacture; its form and existence are fully accounted for on the supposition that it was ejected at an early period from terrestrial volcanoes; to picture it as the ultimate form of matter, whirling in myriad streams through deserted skies, and ever and anon, from some fortunate collision, lighting a fitful beacon, and then dying to darkness, is a return to the chaos of the ancients.

It is nearly impossible to trace the course of such an universal law as Evolution without in some way or another seeming to trespass on the domain of Religion. But Evolution is not at variance with Religion, in its highest sense it is a religion in itself. The Evolutionist is humble in the presence of Nature; she represents the last phase of the great First Cause. Others may scoff at her, the child of their God; he loves her, for she is his companion, his mother, and his nurse; she ministers to his pleasures, yet ever works for his advancement; awake, he studies her, for she is the mine of his learning; asleep, he dreams on the unseen working of her wondrous laws; he listens, he sees, and ever he wonders, but he worships not for he has no fear.

If he lives his life well, he goes not unrewarded, his frame and his mind will live long through the ages; if he lives his life

ill, his doom lies written clearly before him; to succeed best he studies the great book of Nature, he cares but as an antiquarian for the book of the Jews. Nobler inducements has he to act righteously than the most learned and pious divine. If he sins, he knows well that the future will be tainted by the deeds he has done. He it is not that does right lest his Soul should for ever be lapt in noisome sulphureous flames; he shuns evil that he may leave behind him a purer, and a nobler form, that he may hand down to posterity habits that advantage the race as a whole, that he may, however humble his sphere, contribute in some way to the happiness of the future race, and mitigate its inheritance of pain. Long, long, has beneficent Nature worked to that end unaided, may she now find an unselfish ally in her reasoning offspring—Man!

The main objection that can be taken to

Evolution as a scheme of Nature is its fatalism; admit that each successive development of Nature was the result of prior conditions, and it becomes necessary to suppose that the whole present aspect of the universe, together with every most trivial change that may have happened during its history, was certain from the first. A belief in the unaided working of purely natural laws must inevitably lead to the conclusion that Man is not, in the proper sense of the term, a "free agent." He, being but the outcome of natural laws, is subject ever to their guidance; as, from the conditions at the Beginning, nothing that has happened could have happened otherwise than it did, so every trivial action and thought of Man is dictated by the balance of the forces of Nature. Little can he understand their working; ever accustomed to their control, he feels not the pressure of their guidance,

but attributes each motive tendency experienced to the action of a something he calls "Will."

In the inanimate world phenomena often seem to depend on chance; yet our philosophers tell us that no such thing as chance exists,—that every event, however unusual, or however difficult to foretell, proceeds as a most inevitable conclusion from the operation of unvarying laws;—the events appearing chance to us because we cannot trace the governing laws through their interminable maze of cause and effect. Do we shake dice in a box, the number we throw appears chance,—but it really depends on the way the dice were put into the box, the vigour and direction of the shaking, and a number of other causes so intricate and involved that we, unable to follow their operation, ascribe the result to chance. This on a larger scale is the evolutionist's argument; we are the

dice, Nature is the dice box, and the players are the laws of Evolution; all our actions proceed as inevitable conclusions from our environment.

Of course all argument as to the nature of what we call "free will" must be futile; it is here merely intended to point out that, *if* evolution has proceeded steadily from the beginning, it must be held by any consistent reasoner that the future course of events was latent in the primordial form, and that its development on certain lines was assured down to the minutest details.

To many it may appear so certain that in their every deed free will is exercised, that they may discard the evidence in favour of evolution on account of its incompatibility with their dogma. And, in truth, the creed of the fatalist seems so incredible, and is apparently so opposed to energy and progress, that the most eager evolutionist may

well hesitate ere he embraces all the necessary corollaries of his doctrine. Indeed, under this view of the world, the future must be just as certain as the past; its only uncertainty arising in our own inability to estimate the balance of the innumerable forces in action, and so to foretell the subtle reactions of cause and effect. On an unbiassed consideration all the evidence of reason seems to point in favour of Fatality, yet so strong is the whispering of a secret pride, that he is a strong minded man indeed who can believe his will powerless for good or evil.

In comparing the laws which determined the Evolution of Living Bodies, and of Chemical Forms, the closest analogy is observable. In Life, the fittest survive, and all forms not amenable to the existing conditions (whether of race-warfare, or climate) die out. In Chemical Nature, the fittest

survive, and all forms not amenable to the existing conditions are destroyed and re-destroyed until fitter forms are obtained. In both, every slight change reacts more or less on the conditions, which are thus continually (slightly) altering; and in both, forms may be destroyed, or may thrive, according to the neighbouring forms with which they may be brought in contact.

In Organic Evolution, millions of individuals, species, and even whole types, have dropped out, leaving forms representative of every epoch, present all at the same time on the Earth.

In the Inorganic, similar gaps have been left during Time's progress, and substances probably characteristic of many diverse epochs now remain.

In both, man, by changing the environment, can gradually enact the part of Nature, and produce new forms. The high

and inert chemical substance contains hidden within itself the various developments of the primal form, and in a parallel manner the living organism betrays in the growth of its embryo the various stages through which at one time the source of life of the being had passed. But this last is rather a fanciful resemblance; yet so many of these resemblances, fanciful, or real, will occur to a thoughtful mind, that they indubitably tend to show both series of facts to be controlled by one grand Master Law. As the simple protoplasmic cell has become developed into the highly organised vertebrate, so the simple primordial atom of matter has become diversified and developed into the highly complex molecule of the bodies now existent on earth.

If the atomic weight of a body be indeed not the fixed invariable weight of each individual atom, but the *average* weight of a

multitude of atoms, themselves varying slightly in weight, an additional analogy would hold good between the families of Inorganic, and of Organic Evolution. The individuals in each case would vary slightly from each other, but not sufficiently to impair their similitude to the type to which they belong. Any chemical substance would thus be a congeries of minute individuals differing slightly from each other, but only within defined limits; the properties pertaining to it would be the average of the properties of its individual components, in the same way that the characteristics of the genus Homo are not those of any particular human being, but the average of those of the various members of the race taken as a whole.* The limits within which variation

* Recent research would tend to bear out these views. Indeed—though it seems heresy to say so—the differences in the atomic weights of various

may take place, have, in Organic Evolution, been fixed by Natural Selection, being, as we have seen, probably dependent on the intensity of the changes in the environment. It is probable that, in a similar manner, the limits within which the different atoms of a chemical body may vary, have been determined by the "survival of the most inert" among the atoms of matter existent during, and affected by its birth. These limits may, and probably do, vary with each body, though our knowledge of the ultimate particles of matter is not sufficient to raise such conceptions above the region of vague speculation. In this direction, however, sooner than in any other, a glimpse of the genealogy of the elements will in all likelihood be obtained.

elements, as determined by various observers, may be due not to inaccuracies of experiment, but to the substance operated with having been obtained from different chemical sources.

Prof. Crookes has shown that the two extreme bodies obtained by the fractionation* of Yttrium, while differing in chemical properties, and in their phosphorescent spectra, yet give identically the same spark spectrum as each other, and as the parent Yttrium from which they were separated out. These bodies, and their intermediaries, differing though they do in properties, yet form, when mixed, the conventional element Yttrium, and show by the spark spectrum an evident community of descent. Thus, by an artificial selection, long-continued, the dissimilar atoms of the original element

* Fractionation is a process in which, by the addition of a very dilute reagent in a quantity insufficient to cause complete precipitation, a tendency for those atoms with the sharpest affinity, to unite, rather than the more inert ones is obtained. This process is repeated on the two results of each step almost endlessly, till at last a real difference in chemical properties is obtained.

have been sorted out: each group has slightly different properties; each gives a different phosphorescent spectrum; but each under the intense heat of the electric spark again gives but a single spectrum, that of Yttrium itself. What other inference can we draw than that each by that temperature has been momentarily decomposed into its less inert progenitors, common to all alike?

These facts, indeed, taken collectively, would almost seem a proof of evolution, only the fractionation of Nature has taken place, not by mechanical precipitation in a liquid solution, but by a process of chemical precipitation of the inert form (by means of slow cooling) from a fiery gas. The formation of the Yttrium elements is probably due to chemical changes on the fringe of the molecule; on dissociation by the electric spark, however, the minor differences disappear, and the parent molecules common to

all, are, for the instant, rendered capable of separate existence.*

The general idea of the scheme of evolution has now been sufficiently set out to enable us to touch on some of the deeper questions connected with its working.

By the doctrine of the Conservation of Energy† no Force once in existence can be annihilated. Its character may be altered, and its power be so diffused as to be almost unrecognisable, but nevertheless it has not been destroyed. The total of Force in Nature is the same, it cannot be increased or diminished; any apparent creation is caused by the modification, or intensification, of a previously existing force. Con-

* Compare Crookes' "Genesis of the Elements," from which the arguments deducible from Yttrium have been taken, with slight modifications.

† See Appendix.

sequently, if these suppositions be true, evolution cannot have been attended by any change in the total amount of Force in the Universe, but only by local alterations in its character and its distribution. Now in a system entirely isolated from anything exterior to itself, the energy possessed by it will remain the same in amount, but will tend of its own accord to undergo such modifications in character as will diminish its availability for the performance of work.* Hence it will seem probable that there has been an Evolution of Forces, either elder to, or more probably, contemporaneous with, the chemical Evolution of Matter. In all likelihood the two proceeded concurrently, acting and re-acting on each other.

It has been seen in the chemical chapter that an examination of the Evolution of Matter tends to point to the original ex-

* "Principle of Dissipation of Energy," see Appendix.

istence of one primordial body at an extremely high temperature. The loss of this temperature, by which the course of the development of Matter was governed, has been there ascribed to "radiation." It was a convenient explanation of an effect with the cause of which, in that place, we were not immediately concerned, but it would be altogether too unscientific an explanation to be put forward seriously. In the first place, while radiation may undoubtedly take place from one point of the universe to another—being in truth, as it were, but an attempt of heat to find its own level,*—not being able to mentally picture bounds to our universe, we cannot imagine it losing heat as a whole to any exterior space. Indeed, such an event would be contrary to the assumption that Force cannot be lost or annihilated, though

* Or really, of the particles of all matter to vibrate in unison.

there is an absolute difficulty of thought here which lies in our inability to realise infinity. Heat too, as far as we know, can only be transmitted by vibrations through some form or another of Matter; we can only suppose that in absolute emptiness, if such can exist, no vibrations could pass. Wherever a medium existed, there a part of our universe still would be, subject in all respects to the universal process of evolution.

Thus, hemmed in on all sides, it seems that whichever the cause that led to the loss of heat by the Universe, it could not have been radiation. Some other cause must thus be sought.

In the stupendous mass of tenuous primordial atoms, of which at first we have supposed the Universe to have been composed, it seems possible to think that the slightest irregularity in the coincident vibrations of neighbouring atoms may have led

to a substitution of motion of translation for motion of vibration in a part of the mass. In this way it is possible to conceive that the original force of Nature, Heat, may have become diminished in intensity by reason of its gradual metabasis into other forces, in conformity with the principle of the Dissipation of Energy. It is certain that the principal forces of Nature may, by the agency of matter in peculiar states, be changed one into another. Now at the state we suppose as a starting-point for evolution,—a highly tenuous form of matter at an enormous temperature,—the chemical affinities of the atoms of the matter were dormant, owing to the temperature of the mass. Chemical combination could not have taken place, and owing to the sameness of the matter, such forces as Electricity and Magnetism, which must be considered more or less as secondary or induced forces, could

not, under the conditions predicated, have existed.

Could we only clearly see by what means heat first became lost or locally altered to another force, a definite scheme of the progress of Nature in the past would lie before us; whether that scheme would be a probable history of affairs, or only an illusory speculation, is a point for the judgment of others; in the hope that it might at any rate prove of interest it has been detailed here.

The terms Heat and Cold are merely comparative, and is impossible to guess approximately at what temperature the primordial matter of the universe originally existed. Certain it is, however, that by whatever means induced—by the granulation and gravitation of its particles, or what not—this body undoubtedly at a period previous to the evolution of present mattor

acquired terrific heat. It is only from this stage that we can trace the course of evolution at all. Let us see under this conception what the factors of our problem are from which all the subsequent developments of Nature have to be produced.

In the first place we have Matter—not matter as it is now seen in all its various and modified forms—but matter in the term of one, probably homogeneous, subtile gas, of extraordinary rarity and immense chemical energy. Gravity was active in its mass, and particle by particle, each portion of that mass attracted its fellows. Heat, whether born of the last force or not, was present in great intensity, and motion, in the form of motion of vibration, existed also. Chemical affinity was inoperative; its energy was stupendous, but it was as yet merely potential. With the only form of matter uniform and same, it seems doubtful if

Electricity could then have existed. Light, too, if in existence, would probably have been of a lambent phosphorescent character:* in such speculations, however, the imagination is forced to overstep the safe boundary of reason.

The condition, then, which we postulate to account for the past course of evolution, is an extremely tenuous form of matter in which the tendency to chemical inter-union is held in check by the terrific temperature, but in which Gravity is ever free to act on, and accentuate any local disturbance. Could now in any manner any portion of this heat be lost? And it is certain, as far as any human knowledge can be certain, that in the past, as in the present, that portion of the universe of which we have any knowledge, *has* lost heat enormously. If it could, and if this step can only be

* On account of the absence of solid particles.

explained, the tracing of the other processes will be comparatively easy. It should be borne in mind that the failure to explain how this heat has been lost does not affect the general argument; millions of stars undoubtedly are losing heat at this very moment, but any failure to explain how that energy is expended would not at all affect the fact that the heat is lost.

Suppose by any means—by the fortuitous concurrence of harmoniously vibrating atoms, for example,—motion of vibration in any part of the body were to lead to motion of translation. The equilibrium would be upset; gravity would act with increasing force round the scene of the disturbance, part of the energy of heat would have been converted into direct motion, and spheres would have been aggregated, which under the influence of gravity would have tended to densify. Under this view the heat must be

looked upon as having been expended in causing motion, and to this cause the motions of the heavenly bodies would be ultimately attributable.

When the loss of heat had reached a certain point, the chemical energies would be suddenly permitted to come into play; union would take place, more heat be evolved, dissociation follow, etc., as has been pointed out in the chemical chapter. As this gradual evolution proceeded, always working on the lines of the "survival of the most inert," the forces of heat, and chemical affinity, acting on the different molecules of the various chemical forms, would have tended in many instances to have been expended in electrical energies. Hence it seems probable that while the molecules of the evolving matter became denser, and more inert to their environment, that environment was continually changing, not

only by a gradual reduction of the general temperature, and a continuous neutralisation of chemical energies, but also by the birth of new forces.

If only the chemistry of high temperatures were better known to us, the stages of this development might be more easy to follow; at present it seems as if merely the general scheme of action can be traced, the numberless details, and countless reactions, and cross-influences, entirely overwhelming the mind in its effort to disentangle them. And if it be considered that with the formation of each new form a new environment was born to its fellows, it is easily seen how multitudinous must have been the reactions, and how utterly impossible it is for us in the present state of our knowledge to follow them. The result of this turmoil of conflicting attractions has been matter as we now know it, reducible, however, in its

various forms, to some seventy or so, relics of those stormy times, the most stable, or inert of their kind. These seventy or so elementary forms, represent the furthest limits reached by Science in her endeavour to trace back from present matter its earlier parent forms. The conditions at our disposal are not powerful enough to reproduce the environments under which their components were capable of existing, all that we can at present do is to compare the properties of these, to us, elementary forms, and from such comparisons infer, if possible, the nature of the process which led to their formation. A study of the atomic weights of these bodies, expressed in terms of one of their number, reveals a quantity of most curious relations, the chief among which, perhaps, is Newland's law. The key to the descent of the elements and so of all matter, lies hidden here; some day their degrees of

cousinship will be determined, and the constitution of their molecules mapped out, but till then their atomic weights seem but a chaos of figures.

Possibly the theory set forth in this book may have appeared to a scientific reader so highly speculative in its character as to be scarcely worthy of serious consideration. On this account it may be useful to trace back the various evidences of the past, in order to show, in a condensed argument, the bases on which its suppositions really rest. In the first place, we find that the multifarious forms of matter in existence around us at the present day tend to become fewer and fewer, and more simple, according to the intensity of the environments with which we surround them. True, at a certain point we meet a line of demarcation beyond which we cannot at present go, but were the powers at our disposal

more limited, a similar line would be formed nearer to us; and as it is, that line of "elements" has several times of late years been broken back in places, and even now displays several points which we inwardly feel to be vulnerable. There is a vastly greater probability that the substances forming this line of matter-factors seem simple to us merely because our powers of inter-division are only partially developed, than that they themselves are indivisible and indestructible units, of which somehow our universe has been formed. Under this latter view, seventy or so special acts of creation would have been necessary, for it is impossible to imagine any one condition under which those elements could have contemporaneously co-existed before developing into worlds. It would make a very pretty puzzle of "The wolf, the goat, and the cabbage" character, to place the various elements together under conditions where they

could thus exist without being mutually "swallowed up."

In laying down a law that our analysis of matter can proceed no farther than these elements, a new and arbitrary departure is made in direct opposition to the path of experience. It is as if at one stage in a science, it were said: "Thus far your science has triumphantly carried you, but it is true no further; the present marks the limits of your knowledge; human intelligence can make no deeper discoveries; Time will unfold nothing new." It can scarcely be credited that any reasoning man can take up such a position. Matter may thus be taken for the purposes of the argument to be merely various phases of an ultimate form.* It has been endeavoured to be

* Or, possibly, of a few ultimate forms. Certain it is, however, that these ultimate forms cannot possibly be our present elements.

shown that those phases have depended on the conditions of the environment in the present and the past.

The form of the Earth shows that at one time it was certainly wholly in a molten state, its mass probably is so still,* while its crust, as evidenced by the study of geology, has gradually passed from a fiery active state, to the condition of comparative quiescence we now see. Such alterations have, we know, been attended by the modification of previously existing matter. La Place's Nebular Hypothesis supposes at a past period the existence of the whole solar system as an huge mass of fiery vapour. Under such conditions we know the matter

* A standing evidence of how extremely slowly cosmic bodies lose their heat, and additional evidence, if any were needed, that the contention of some physicists as to the extremely limited age of the Sun, must in all probability be utterly erroneous.

of the Earth could not have existed in its present state; its present forms must have been assumed as the result of numerous chemical reactions during the slow cooling. In such a case, a species of evolution, or selection of the forms most inert to the successive environments, must inevitably have taken place.

We know that chemical combination almost invariably produces heat, also that extreme heat causes dissociation, or, which is a similar thing, prevents chemical union. Thus, as heat was gradually lost, fresh chemical unions would have been permitted, and thereupon fresh heat would have been replaced. When volumes of two or more gases combine together to form a new compound, two volumes only of the new body (when in the gaseous state) are formed. Hence when the cooling took place which led to chemical union, a great shrinkage

in volume must, at nearly every stage, have taken place also. Thus, matter tended to become denser and denser, and to occupy successively smaller and smaller space, as evolution proceeded.

Having thus to a great extent circumstantial evidence of the course of evolution in its more recent periods, is it straining probabilities to suppose that this was merely a continuation of a previous process?—That the evolution of present matter from the fire vapours of the solar system, was analogous to the evolution of the fire vapours from the universal primordial vapour of all Space? The inference seems a fair one. The enormous distances now existing between the astral bodies would have been partly caused by shrinkage of the matter from loss of heat, partly by the collapses due to Gay Lussac's law.

There are degrees of temperature above

and below which any sets of bodies will not combine with each other; these limits differ with the different bodies, and must have played a most important part in evolution. Thus, bodies may have co-existed passively some hundred degrees higher up, which at a lower temperature would have combined immediately. Of course, as in Organic Evolution, original differences would have tended to have widened with time, and the descendants of each type to have become more and more distinct.

It may be noticed that if we look upon all matter as being immediately reducible to two or more parent bodies, it would seem that the number of more active ancestral bodies should be greater than that of their more inert descendants. Yet we have supposed a single primordial form to account for all the present ramifications of matter; the apparent contradiction is owing to so

many of tho ancestors in the past having been common to different descendants. The same apparent paradox will be seen in the genealogy of a tribe, or of organic evolution generally. One difficulty that accounts for our inability to break up the elements, and so discover these ancestral forms, is that tho means at our disposal to produce the power necessary, is the heat given out by the combination of bodies which should, by our theory, be more inert than the constituents of the element acted on. If chemical affinity be brought to aid the dissociation, the activity of our agent is unlikely to be so strong as that of the "element's" constituents. Hence the difficulty in reducing the early inert forms that have survived to the present time, and which we know as elementary bodies.

It has been intended by the foregoing

arguments to show the probability of the gradual development of the present Aspect of Nature from a much simpler beginning.

It has been attempted to be proved that all matter is ever in a transition state, and that it is continually being modified along certain well-defined lines, slowly, yet full surely, by the action of forces from which it is inseparable.

What these "forces" themselves are;—chemical force, gravital force, and all the various forces of nature;—whether they are separable from, or inherent in, matter, seems, alas! impossible to be determined. We, poor beings, so saturated are we with our environment, can imagine no Matter without Force, and no Force without Matter. And indeed, many have supposed the one to be but a particular form of the other.

If the idea of the Evolution of all Matter in the way described be ever accepted, the

next problem would be the Evolution of Force. For while it is believed Energy cannot be lost, it is known that different forms of Matter, when acted on by an Energy or Force, yield often different Energies. Matter, in other words, acts as a medium for the conversion of Force, and the manner of the conversion, and the result, depend largely on the molecule of the Matter. The tendency of the Evolution seems to be towards the dying out of chemical energy and heat, and the birth and growth of numerous delicately balanced forces, depending in each case on the different characters of the molecules acted on.

If the one theory be ever accepted, this other development is sure to follow, but it can hardly be touched upon at all until the Evolution of Matter has reached a far more substantial basis than that on which it now rests.

It cannot be too strongly borne in mind in weighing the value of scientific teaching, that the evidences Science yields to our consciousness are not definite rigid facts, but merely the interpretation, through the agency of our senses, of external phenomena. It by no means follows that the whole of the phenomena are transmitted;—if our senses, as is supposed by evolutionists, have been formed by the perpetuation, and gradual perfection of nerves sensitive to such external phenomena as in their perception may have proved valuable to the organism in its struggle for existence, then multitudes of forces must in all probability exist around us, unsuspected and undetected, in consequence of the non-formation in the human animal of an organ sensitive to their action.

How various, extraordinary, and even contradictory, those unknown forces may

be! How narrow, and even false, those generalisations drawn from tho perceived phenomena that Man dignifies by the name of Laws! Yet of such is the Goddess Science, whose features no man may see: her stature groweth with the years: her form changeth with the times: her person in the effulgence of its majesty no human thought can limn!

APPENDIX.

Epitome of the Chief Laws and Theories Made Use of in the Foregoing Arguments.

*Nebular Theory.**—"It is supposed that our sun had once a stupendous nebulous atmosphere, which extended so far out as to fill all the space at present occupied by the planets. This gigantic nebulous mass, of which our sun was merely the central and somewhat more condensed portion, had a movement of rotation on its axis ... As this vast mass cooled it must by the laws of heat have contracted towards the centre, and as it contracted, it must, according to a well-known law of dynamics, have rotated more rapidly ... The time would then have come

* Extract from article by R. S. Ball, L.L.D., "Encyc. Britt." Vol. 17.

when the centrifugal force on the outer parts of the mass would have more than counter-balanced the attraction of the centre, and thus the outer parts would have been left as a ring. The inner portion would still have continued to contract, and thus a second ring would have been formed, and so on ... The materials of each ring would continue to cool and to contract, until they passed from the gaseous to the liquid condition ... The effect of such contraction would be to draw into a single mass the materials of the ring, and thus a planet would be formed, while the satellites of that planet would be developed from the still nascent planet in the same way as the planet itself originated from the sun ... It can be shown that the sun is at present contracting so that its diameter diminishes four miles every century. Dealing then simply with the laws of nature as we know them, we can

see no boundary to the growth of the sun as we look back. We must conceive a time when the sun was swollen to such an extent that it filled up the entire space girdled by the orbit of Mercury. Earlier still the Sun must have reached to the Earth. Earlier still the Sun must have reached to where Neptune now revolves on the confines of our system; but the mass of the Sun could not undergo an expansion so prodigious without being made vastly more rarefied than at present, and hence we are led by this mode of reasoning to the conception of the primeval nebula from which our system has originated."

*Law of Newland's and Mendeljeff.**—"If the elements are arranged in the order of their atomic weights from H = 1 to U = 240, it will be found that, with the exception of certain gaps, the relations between their

* Extract from Miller's Chemistry, part ii., p. 974.

properties, their quantivalence, and their atomic weights, takes the form of a periodic function. This periodic law was first pointed out by Newland's in 1864, who called it the law of octaves, as he observed that when arranged in this way, every eighth element, starting from a given one, was a kind of repetition of the first, like the eighth note in the musical octave. Thus, if the fourteen elements whose atomic weights lie between 7 (Lithium) and 35·5 (Chlorine) be arranged in two groups of seven,

1	2	3	4	5	6	7
Li=7	G=9·4	B=11	C=12	N=14	O=16	F=19
Na=23	Mg=24	Al=27·3	Si=28	P=31	S=32	Cl=35·5

it will readily be seen that the first and eighth members of the series, Lithium and Sodium, are closely allied in properties; and the same may be said of the second and

ninth (G and Mg), the third and tenth (B and Al), the fourth and eleventh (C and Si), and so on." This law, thus crudely stated, has been greatly extended of recent years, and most interesting curves showing the periodic relations of Valency, Para- and Dia-Magnetism, and other properties, have been worked out. It should be here stated that in any group of elements (*i.e.*, any series of corresponding octaves) the body with the heaviest atomic weight tends to be the least chemically active, and *vice versâ*.

*Atomic Theory.**—"Though every visible fragment of matter admits of further division into a vast multitude of minute particles, there is a limit beyond which this process of sub-division cannot be carried by any known method, chemical or mechanical. These ultimate or indivisible particles are what are called the atoms of the elements.

* Extract from Miller's "Inorganic Chemistry."

The atoms of any particular element are further supposed to be exactly equal to each other in size and in weight, and when at the same temperature, to be absolutely like one to another in all respects. But the atoms of any single element differ from those of all other elements in chemical properties as well as in weight. Further, whenever chemical combination takes place between any two elements, it is assumed that union occurs between their atoms ... The atom is the smallest and chemically indivisible particle of each element which can exist in a compound, united with other particles, either of the same or of different elements, but which is not known in a separate form; the molecule of an element is the smallest quantity of that elementary substance supposed to be capable of existing in a separate form."

These are more or less hypothetical de-

ductions from Dalton's laws of proportions, which latter are so fundamental that they need not be detailed.

The form of atoms is supposed to be that of a vortex ring (Sir W. Thomson).

Gay-Lussac's Law of Volumes.—Gases combine together in equal volumes, or in volumes which have some relation one to another, as one volume to two volumes, one to three, two to three, and so on; and whatever the number of volumes of the combining gases in their original uncombined state, the bulk of the resulting compound measured in the gaseous state under the same conditions of temperature and pressure, is always *two volumes.**

Law of Avogadro.—Under the same conditions of temperature and pressure,

* Abridged from Tilden's "Introduction to Chemical Philosophy."

there are in equal volumes of all gases an equal number of molecules.

Law of Dulong and Petit.—The specific heats of the elements are inversely proportional to their atomic weights; in other words, the product of the specific heat of any element multiplied by its atomic weight is a constant number. This law, though the better known, is only a particular case of the succeeding, Naumann's law.

Naumann's Law.—"With compounds of the same formula, and of a similar chemical constitution, the product of the atomic weight into the specific heat is a constant quantity."*

Doctrine of Conservation of Energy.—"The total energy of any body or system of bodies is a quantity which can neither be increased nor diminished by any mutual action of those bodies, though it may be transformed

* Ganot's "Physics."

into any one of the forms of which energy is susceptible." *

Doctrine of Dissipation of Energy.—"If a system be removed from all communication with anything outside of itself, the whole amount of energy possessed by it will remain the same, but will of its own accord tend to undergo such transformations as will diminish its availability." Availability is the term given to the ratio of the portion of the energy of a system which can be converted into work compared with the total amount of energy present.†

Meteoric Theory.—This is a new theory according to which the stellar and planetary bodies and systems have been formed by the collision of meteor-swarms. These meteors were supposed to have been formed by a process of "curdling" from a primitive

* "Encyc. Britt." Vol. viii., page 207.

† "Encyc. Britt." Vol. viii., page 210.

matter, but were themselves the first appearance of chemical matter, properly so-called. They were mostly of extremely fine size, and, endowed from the first with motion, swept in enormous streams and eddies through Space. Where their motion was not quite uniform collisions occurred, and heat was evolved till finally coalescence resulted; gravity acted with increasing force from the larger mass, fresh meteoroids were attracted, till finally a sun suffering incessant meteoric bombardment was the result.

The evidence on which this theory mainly relies are the low temperature spectra analogies of some nebulæ with meteors. The existence of meteors is also thought to be indicated by the striated appearance of many nebulæ, and the "ring" formation of others.

It may be pointed out, however, that while the spectroscopic identities of meteors

and nebulæ would undoubtedly tend to show the presence of similar matter in each, they distinctly do not show that the nebulæ contain meteors. Striæ and wavy curves—especially in spiral nebulæ—point at least as much to rushes of vapour as to meteor streams.

Comets are apart from the argument: they, probably of much later birth, may very likely have had a meteor origin, and the eccentricities of their orbits may have been due to the collision and mutual interference of the swarms.

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